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(71) Applicant: **Norsk Hydro ASA**  
**0240 Oslo 2 (NO)**

(72) Inventors:  
• **Auran, Lars**  
**6600 Sunndalsora (NO)**  
• **Furu, Trond**  
**6600 Sunndalsora (NO)**

(74) Representative: **Bleukx, Luc**  
**Norsk Hydro Technology B.V.,**  
**Avenue Marcel Thiry 83**  
**1200 Brussels (BE)**

(54) **High extrudability and high corrosion resistant aluminium alloy**

(57) An aluminium-based alloy consisting of 0,10 - 0,40% by weight of iron, 0,05 - 0,25% by weight of silicon, 0,05 - 0,20% by weight of zirconium and the balance aluminium and incidental impurities, said aluminium-based alloy exhibiting high corrosion resistance and high tensile strength. Optional elements are 0,05 - 0,40% by weight of manganese and 0,05 - 0,30% by weight of chromium.

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## Description

The invention relates to an improved aluminium alloy and more particularly relates to an aluminum alloy which contains controlled amount of defined compound and is characterised by the combination of high extrudability and high corrosion resistance.

In the automotive industry, aluminium alloys are used in a number of applications, especially for tubing because of the extrudability of the alloys combined with high strength and relatively high weight.

Especially useful are aluminium alloys for use in heat exchangers or air conditioning condensers. In this application the alloy must have a good strength, a sufficient corrosion resistance and a good extrudability.

A typical aluminium alloy used in this application is AA 3102. Typically this alloy contains 0,15% by weight of Si, 0,20% by weight of Fe and 0,25% by weight of Mn.

There is a constant need for having aluminium alloys, having the combination of excellent extrudability and superior corrosion resistance. Excellent extrudability is required to minimize production costs at the extrusion plant, including lower extrusion pressure and higher extrusion speeds.

It is therefor an object of this invention to provide an aluminium alloy composition which exhibits superior corrosion resistance and improved extrudability. The aluminium alloy of the present invention includes controlled amounts of iron, silicon, manganese and zirconium.

The manganese content is limited to improve the extrudability of the alloy and to offset the effect of the zirconium alloying component which causes the flow stress of the aluminium alloy to be higher than alloys without the addition of zirconium.

It is a further object of the present invention to provide an aluminium-based alloy, suitable for use in heat exchanger tubing or extrusions.

It is another object of the present invention to provide an aluminium-based alloy, suitable for use as finstock for heat exchangers of in foil packaging applications, subjected to corrosion, for instance, from salt water.

It is still another object of the present invention to provide a process using a high corrosion resistance.

According to a modification of the invention, there is provided an alloy which contains manganese in an amount between 0.05 - 0.40% by weight.

In this way an alloy is obtained having an improved corrosion resistance and a better extrudability as compared with the alloy containing manganese.

Other objects and advantages of the present invention will become apparent as the description thereof proceeds.

These objects and advantages are obtained by an aluminium-based alloy, consisting essentially of about 0,10-0,40% by weight of iron, about 0,05-0,25% by weight of silicon, about 0,05-0,2% by weight of zirconium, and the balance aluminium and incidental impurities, said aluminium-based alloy exhibiting high corrosion resistance and being capable of being extruded using a high tensile strength.

In a preferred embodiment, the zirconium content is limited to an amount between 0.10 - 0.18% by weight, more preferable between 0.15 - 0.18% by weight.

In a modified form of the invention the alloy contains in addition 0,05 - 0,40% by weight of manganese.

In a preferred embodiment of this modified invention the zirconium content is limited to an amount between 0,10 - 0.30% by weight, and more preferable the manganese content is limited to an amount between 0,20 - 0,25% by weight.

According to other preferred embodiments of the invention the chromium content is limited to an amount between 0,05 - 0,30% by weight, preferably between 0,08 - 0,10% by weight, and more preferably between 0,08 - 0,10% by weight, the iron content is limited to 0,15 - 0,20% by weight and the silicon content is limited to 0,10 - 0,25% by weight.

In an effort to demonstrate the improvements associated with the inventive aluminium-based alloy over known prior art alloys, properties related to mechanical properties, corrosion resistance and extrudability were investigated.

The following description details the techniques used to investigate the properties and discussion of the results of the investigation.

Two compositions were selected for comparison purposes with a preferred invention alloy composition. The two compositions are designated as alloy A and alloy B; alloy A being an average 3102-alloy as practically used in the extrusion of heat transfer components, such as multiple port extrusion tubes, alloy B corresponds to a composition as described in the US-A-5286316.

The preferred embodiment of the invention alloy is designated as alloy I, whereas another alloy according to the invention in designation alloy II

In table A there are shown the compositions of the alloys, A, B and I.

**TABLE A**

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			Fe %	Si %	Mn %	Cr
10	Alloy	A	0,41	0,08	0,24	-
		B	0,2	0,08	0,29	-
		I	0,18	0,08	0,24	0,16
15		II	0,12	0,1	-	0,16

20 For investigation of the properties of their alloys, a set of billets were cast and homogenized.

For determining the corrosion resistance of these alloys, use is made of the so-called SWAAT-test. This test was performed according to ASTM-standard G85-85 Annex A3, with alternating 30 minutes spray periods and 90 minutes soak periods at 98% humidity. The electrolyte is acidified, with acetic acid, artificial sea water with a pH of 2,8 to 3,0 and a composition according to ASTM standard D1141. The temperature is kept at 49°C. The test was run in a Liebis

25 KTS-2000 salt spray chamber.

In order to study the evolution of corrosion behaviour, samples from the different alloys A, B, I and II were taken out of the chamber at the following moments : after 2 days (1); 6 days (2); 12 days (3); and 23 days (4).

The materials were then cleaned in water and subsequently cleaned in chrominium-phosphoric acid.

The end results of the SWAAT-test are shown in table B.

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**TABLE B**

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	sample	SWAAT Days
	alloy	
	A	13
40	B	25
	I	36
	II	20

45

From this data it will be clear that the alloy I and II according to the invention has superior corrosion resistance as compared with the alloy A, but alloy II has somewhat lesser corrosion resistance as compared with the alloy B.

50 In order to further compress the tested alloys the following mechanical characteristics of the alloys have been measured: Rp0.2, Rm and A10, as well as some extrusion characteristics such as the Die Force and the Extrusions Force.

The mechanical characteristics have been measured in accordance with Euronorm NS-EN10002-1, First edition of October 1990. The obtained values are expressed in HPa, MPa and % respectively.

55 The die Force and the Extrusion Force have been measured by means of pressure transducers, mounted on the press, after which the obtained values have been recalculated in order to express the obtained values in Tons.

The measured values are represented in Table C.

TABLE C

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	Sample	Rp0.2 (HPu)	Rm (HPu)	A10 (%)	Die Forces	Extrusion Forces
					Tour	Tour
	<b>Alloy A</b>	47,5	87	47,8	1844	2438
15	<b>B</b>	45,7	84	46,5	1929	2453
	<b>I</b>	49,7	89	39,9	2100	2480
	<b>II</b>	-	-	-	1960	2480

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From these results it will be clear that the alloy I and II according to the invention has improved mechanical properties compared with the alloys A and B, whereas the extrudability is maintained at an acceptable level.

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**Claims**

1. An aluminium-based alloy consisting essentially of about 0,10 - 0,40 % by weight of iron, about 0,05 - 0,25 % by weight of silicon, about 0,05 - 0,20 % by weight of zirconium and the balance aluminium and incidental impurities, said aluminium-based alloy exhibiting high corrosion resistance and high tensile strength.
2. The alloy of claim 1, wherein said zirconium content ranges between about 0,10 - 0,18 % by weight.
3. The alloy of claim 2, wherein said zirconium content ranges between about 0,15 - 0,18 % by weight.
4. The alloy of any of the claims 1 - 3, modified in that it comprises in addition about 0,05 - 0,40 % by weight of manganese.
5. The alloy of claim 4, wherein said zirconium content ranges between 0,10 - 0,30 % by weight.
6. The alloy of claims 5, wherein said manganese content ranges between about 0,20 - 0,25 % by weight.
7. The alloy of any one of claims 1 - 6, modified in that it comprises in addition about 0,05 - 0,30 % by weight of chromium.
8. The alloy of claim 7, wherein said chromium content ranges between about 0,05 - 0,20 % by weight.
9. The alloy of claim 8, wherein said chromium content ranges between about 0,08 - 0,10 % by weight.
10. The alloy of any of claims 1 - 9, wherein said iron content ranges between about 0,15 - 0,25 % by weight.
11. The alloy of any of claims 1 - 10, wherein said silicon content ranges between about 0,10 - 0,25 % by weight.

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## EUROPEAN SEARCH REPORT

Application Number  
EP 97 20 2233

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (InCL6)
X	PATENT ABSTRACTS OF JAPAN vol. 017, no. 492 (C-1107), 7 September 1993 & JP 05 125472 A (FURUKAWA ALUM CO LTD), 21 May 1993, * Examples 6,7,9 * * abstract *	1,2,4, 7-9,11	C22C21/00
X	--- US 4 749 627 A (ISHIKAWA KAZUNORI ET AL) 7 June 1988 * Claim 1; Examples 5,6,12,20 *	1,2,7,8, 10	
A,D	--- US 5 286 316 A (WADE KENNETH D) 15 February 1994 * Claims *	1-11	
X	--- CHEMICAL ABSTRACTS, vol. 098, no. 22, 30 May 1983 Columbus, Ohio, US; abstract no. 184144, XP002050996 * abstract * & JP 57 203 743 A (MITSUBISHI ALUMINUM CO.) 14 December 1982 -----	1-8,11	
			TECHNICAL FIELDS SEARCHED (InCL6)
			C22C
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 22 December 1997	Examiner Bjoerk, P
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